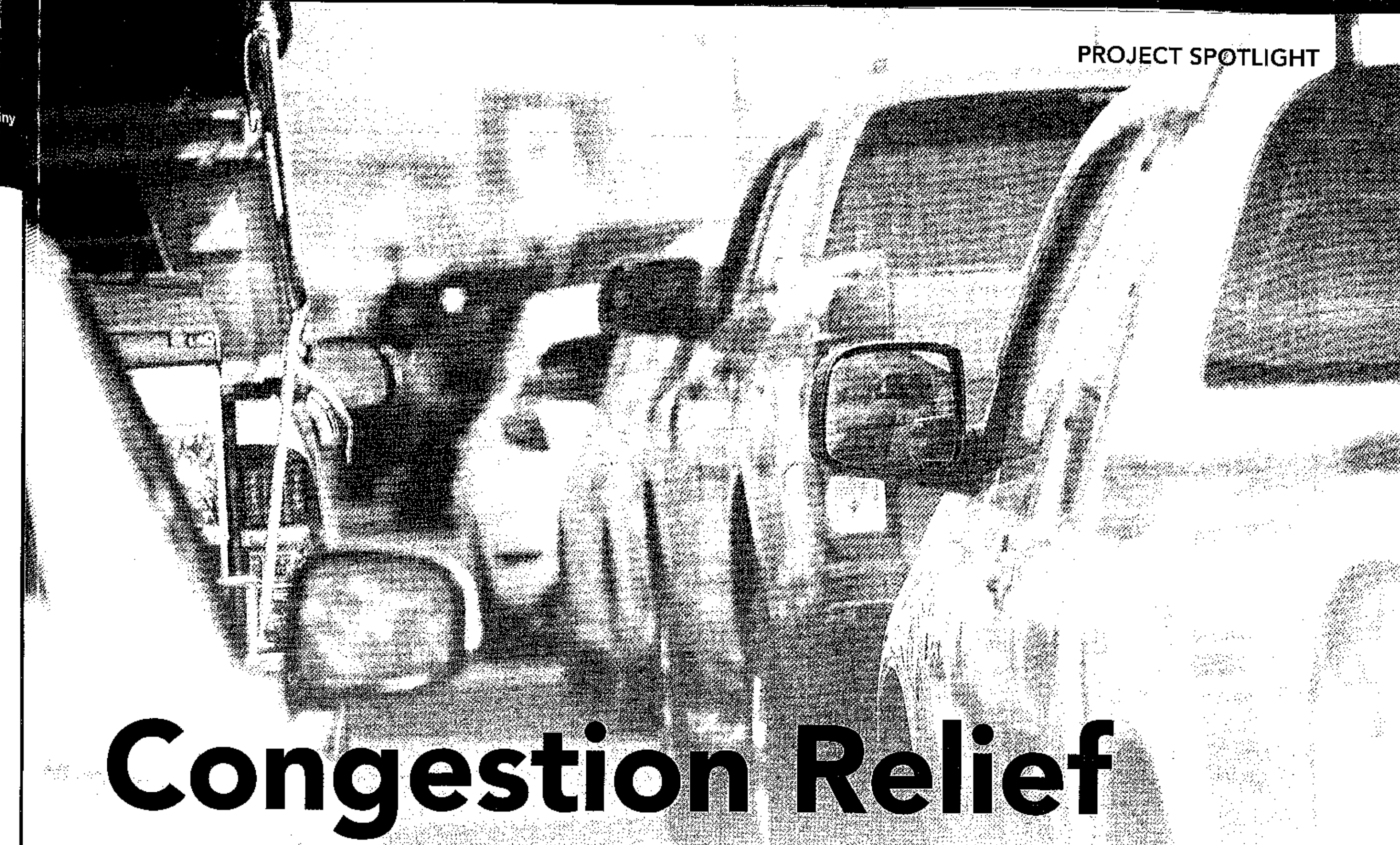


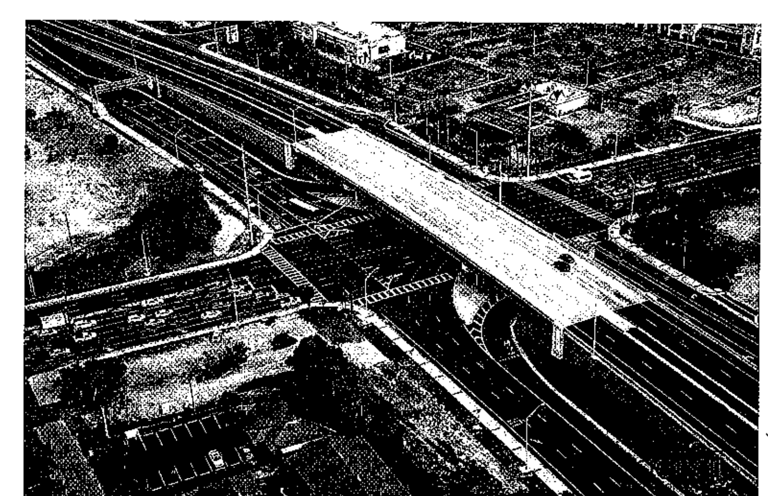
Congestion Relief

GRL Engineers, Inc. worked to help ease congestion at the intersection of Florida's U.S. 17-92 and SR 436

By Mohamad Hussein, GRL Engineers, Inc.

The intersection at US 17-92 and SR 436 is one of the most congested intersections in Florida, with over 100,000 motorists traveling daily through the corridor. Just 13 miles north of Orlando, Fla., the US 17-92/SR 436 intersection serves as a main route for commuter traffic as well as a major pipeline for motorists coming from Interstate 4. The project was contracted as a design-build project to provide a single point urban interchange that was achieved with the design of a flyover bridge to alleviate traffic. Challenges for the project included the Florida Department of Transportation (FDOT)'s set budget, accelerated schedule and the unprecedented delivery and installation of the longest single piece concrete beams ever fabricated and installed in Florida and the United States.

The flyover bridge has drastically helped motorists' travel time since its official opening, with drivers saving an average of five to 10 minutes in their commutes, particularly motorists traveling US 17-92 that don't have to stop for the traffic on SR 436. This is significant because the FDOT's $2-billion, I-4 Ultimate Project was set to begin construction and they wanted the US 17-92 flyover bridge to be in operation before construction began on the I-4 project to facilitate traffic.



Unique design applications/considerations

Prior to construction, the six-lane arterials were subjected to heavy congestion daily, resulting in major delays with motorists' wait time clocking in at four- to five-minute traffic light cycles. A PD&E study conducted on whether to raise the bridge over SR 436 or 17-92 concluded that a single point urban interchange (SPUI) over SR 436 was the best solution due to right-of-way constraints. The flyover bridge is configured in three, simply supported spans with a main span of 209 feet and two approach spans of 124 feet for a total bridge length of 457 feet. The profile for the US 17-92 overpass was developed based on a 45 mph design speed, with three through-lanes in each direction along US 17-92 approaching the new interchange. A 14-foot median, with a traffic separator, is

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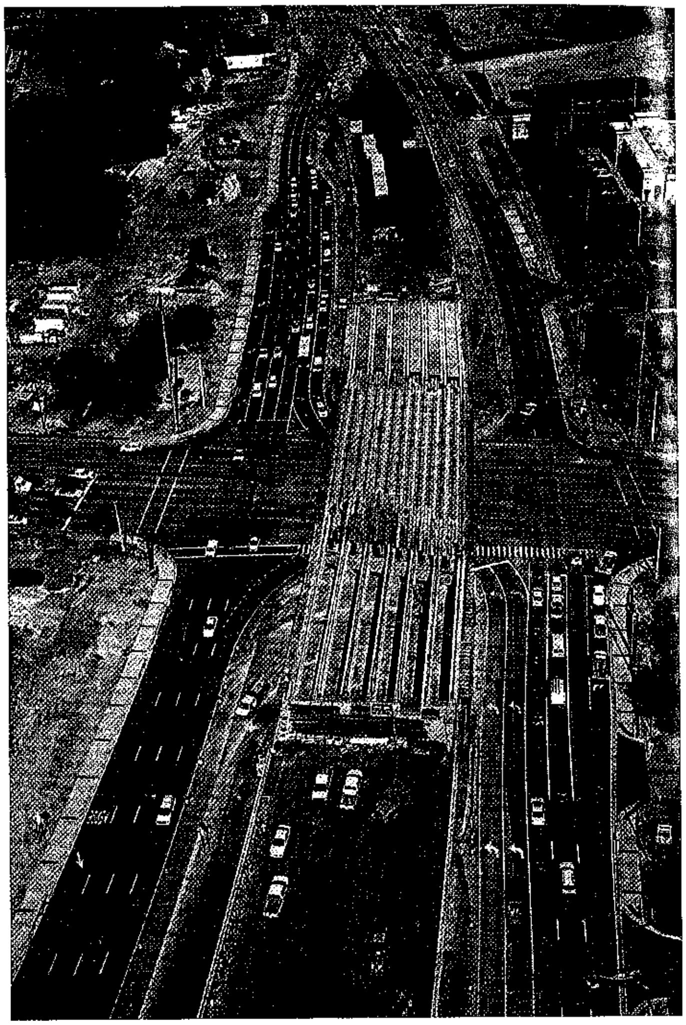

Concrete beams were designed with high-strength concrete (10,000 psi) for increased structural capacity

maintained across the overpass bridge providing for a continuous urban-type median section. The project included: roadway design, structural design, traffic/ITS design, drainage design, surveying and mapping, utility coordination, maintenance of traffic and permitting.

Cost saving measures

Originally designed as two separate continuous steel girder bridges, our team evaluated other options for the flyover bridge. Maintenance costs for concrete was also more economical compared to steel, which would require routine painting and more rigorous inspection. In addition, shoring towers would be needed to facilitate erection if steel girders were used, which would impede traffic on SR 436. The elimination of the shoring towers reduced traffic impacts and simplified the overall traffic control plan. Other advantages of using concrete beams over steel included improved aesthetics, reduced beam fabrication time and reduced erection time. The benefits of concrete coupled with lower upfront material costs resulted in a total savings of approximately $2 million, not including long-term maintenance costs.

Innovation in construction

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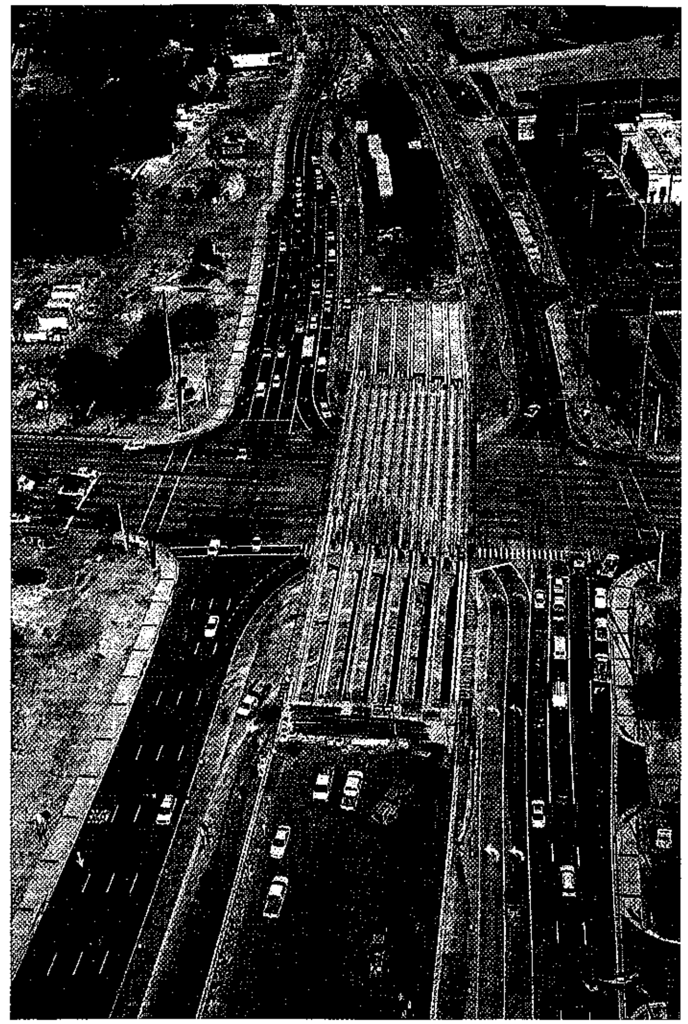

Courtesy of GRL Engineers, Inc.

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The concrete beams were designed with high-strength concrete (10,000 psi) for increased structural capacity, which eliminated a beam line, reducing total beam costs as well as the dead load that must be carried by the substructure. Although a shallower beam would have been adequate for the approach spans, the team used the same beam depth for all the exterior girders to eliminate the discontinuity in the profile of the structure and to maximize the visual appeal. The approach spans consist of 78-inch-deep Florida I-beams (FIBs) and 96-inch-deep FIBs (exterior), and the main span consists of all 96-inch-deep FIBs. Using the 96-inch-deep FIB, the concrete beams were able to span greater lengths, which decreased cost and the construction schedule and increased maintainability.

Construction problems and creative solutions

Delivery and installation of longest concrete beams in the U.S.

Although more efficient and economical, the real test in using concrete beams came in how the team would go about getting 209-foot concrete beams fabricated, delivered and erected. The beams are the longest beams in the state and the pre-casting company confirmed that the beams are actually the longest single-piece beams in the United States.

Traditionally, using concrete beams that are in the 165 to 170-foot range was the upper end of length limitations for concrete beams. With the introduction of Florida-I Beam (FIBs), precast beams are able to span longer and with greater efficiency than AASHTO beams.

Delivery

Working closely with an FDOT-approved pre-stressed supplier, the team addressed the delivery of the thirteen 265,000-pound beams that had to be fabricated and delivered from their site in Leesburg, Fla. The supplier performed a detailed evaluation, coming up with the most cost-efficient route between their plant and the project site. With two special trailer trucks, capable of supporting 300,000 pounds, they delivered two beams each night, making the delivery a full weeklong process. The entire US 17-92/SR 436 intersection was closed down and traffic was rerouted between off-peak hours, 11 p.m. to 6 a.m., each day of that week to accommodate the delivery. Due to the load the trucks were carrying, seven Florida Highway Patrol cars accompanied each truck every night to help ensure safety and a smooth delivery of the beams.

Installation

The construction team used two large cranes to lift the beams from the trucks and place on the piers. The cranes had to operate within a close distance to the relocated power lines. To maintain safety and an effective installation, the contractor implemented their own safety standards – which were greater than OSHA standards. The most significant unforeseen construction challenge was the variation between the predicted camber of the beam and the actual camber. Several factors played into camber differences, including how the beam was cast and additional strands added to the beam for handling. These strands were cut at the jobsite before concrete for the deck was placed. The effect of these strands was more significant than expected. Since the strands were fully stressed when the concrete was at a lower compressive strength, and cut when the concrete was at a much higher strength, camber growth was reduced significantly. The casting bed at the precast facility that could accommodate the 209-foot-long beams was 500 feet in length.

To meet the schedule, two beams were cast in the same bed. While this allowed for a faster production rate, one unintended result was varying camber between the two beams. After all tendons were stressed, the first beam was formed and the concrete placed. After the concrete cured, the forms were stripped and placed for the second beam and concrete was placed. Once the second beam's concrete reached the strength required for transfer, the strands were detensioned and both beams were removed from the bed and placed on dunnage. The difference in concrete strengths at the time of strand release caused variations in camber values when measured at the precast yard. Compounding the issue of camber variation was the construction schedule. A bonus to reduce the project schedule was offered to the contractor after award. This forced the contractor to start erecting beams earlier than the design assumption. The beam age at erection varied from 16 to 58 days. Beams are typically erected at 120 days, which was assumed for design. While all beams had achieved the specified 28-day concrete compressive strength, the large variation in age at erection caused reduced beam cambers and increased variation in cambers.

To get a more accurate estimate of the deflection and the camber, in comparison to the standard design analysis, LARSA 4D, finite element analysis software, was used. Using the software allowed the modification of the live-load distribution factors that exceeded some of AASHTO's parameters. These calculations helped to determine deflections for construction staging to field measure deflections.

Design changes

The substructure for this bridge consisted of two end bents, each containing 13 piles, together with two piers, each containing 44 piles. The pier foundations were divided into three clusters of piles – 16 left, 12 center and 16 right – configured on a 26.5-foot center-to-center group spacing. All piles were 18-inch, pre-stressed concrete. Test pile lengths were designed to be 110 feet long for the end bents and 85 feet long for the interior piers, driven to a bearing layer varying from very dense, claylike sand, hard, silty clay or claystone and sandy limestone.

Static pile capacities were estimated by the geotechnical design engineer (Ardaman & Associates, Inc.) for the piles following standard FDOT procedures and using the computer software "FB-Deep." Design nominal bearing capacity (NBC) of 233 tons for the end bents and 242 tons for the interior piers was indicated as being achievable for piles driven to the hard bearing soils.

Pile driving and testing were accomplished with an APE D30-32s single acting diesel hammer. Pile stresses were well controlled during driving. PDA and CAPWAP® analyses performed by GRL Engineers, Inc. indicated that consistent ultimate pile load bearing capacities of over 500 tons were available, approaching 600 tons in some cases. Since this greatly exceeded the original design capacities for the piles, the decision was made to redesign the left and right clusters of each of the two interior piers to include only 12 piles instead of 16. This increased the design ultimate capacity from 242 tons up to 339 tons, which was still well below the capacity indicated as being available, but more than would typically be applied to an 18-inch concrete pile. In addition, by eliminating the four corner piles from the subject pile cluster groups, only very minor modifications were required to the reinforcing steel in the 16.5-foot square concrete pile caps. Plans detailing the design modifications were rapidly produced and approved by the owner, resulting in uninterrupted progress to the substructure installation. ▼

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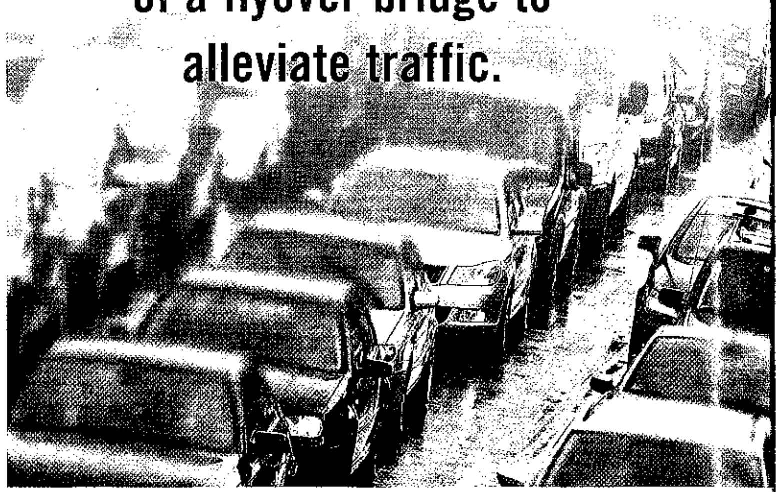

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